

INDOOR AIR QUALITY ASSESSMENT

**Taft Elementary School
16 Granite St
Uxbridge, MA 01569**



Prepared by:
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Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of the Uxbridge School Department (USD), the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at each of Uxbridge's public schools. These assessments were coordinated through Michael Legender, Facilities Director for the USD. On June 1, 2005, Sharon Lee, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment at the Taft Elementary School (TES), 16 Granite Street, Uxbridge, Massachusetts.

The TES is a single story brick building constructed in 1952. Additions were made to the building in 1989 and 1998. The building is structured around two courtyards and consists of general classrooms, music room, library, art room, computer lab, kitchen, cafeteria, gymnasium and office space. Windows were openable throughout the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The TES houses approximately 650 students in grades 1-4 and has a staff of approximately 110. The tests were taken during normal operations at the school. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in 21 of 50 areas surveyed, indicating inadequate air exchange in almost half of the areas surveyed on the day of the assessment. A number of areas with carbon dioxide levels below 800 ppm were sparsely populated, unoccupied or had windows open. Low occupancy and open windows can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy and with windows closed.

Fresh air in both the 1952 and 1998 classrooms is supplied by unit ventilator (univent) systems (Pictures 1 and 2). A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building (Picture 3) and returns air through an air intake located at the base of each unit ([Figure 1](#)). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. The majority of univents were not operating during the assessment. Obstructions to airflow, such as papers and books stored on univents and items placed in front of univent returns, were seen in a number of classrooms (Pictures 1 and 2). In one instance, clay figurines were placed near a univent diffuser so that air passing over the figurines would act to dry the clay (Picture 4). Placing these items

near the supply diffuser can serve to distribute dried clay particles. In order for univents to provide fresh air as designed, these units must remain activated and allowed to operate while rooms are occupied. Univent intakes and diffusers must also remain free of obstructions.

Exhaust ventilation in the 1952 and 1998 portions of the building is provided by vents located in closets, exhausts located in recessed cubbies or ceiling-mounted vents, all of which are ducted to motorized fan units located on the roof. For rooms with closet exhausts, classroom air is drawn through a space beneath the closet door and into the closet (Picture 5). For closet-style exhaust, exhaust vents are located in the upper portion of the coat closets (Picture 6). Closet exhaust vents are prone to obstruction by items placed in front of floor level openings and/or on shelves below the vent. Cubby-style exhaust vents (Picture 7) are also prone to blockage either by larger items placed in front of the cubby or by items placed into the cubby (Picture 8). Lastly, several ceiling-mounted vents are located near hallway doors (Picture 9). When classroom doors are open, exhaust vents for these rooms will tend to draw air from both the hallway and the classroom, reducing the effectiveness of the exhaust vent to remove common environmental pollutants from the classroom itself. As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions.

Classrooms in the 1989 wing and the majority of offices throughout the school have air-handling units (AHUs) that supply fresh air via ceiling-mounted slotted or directional diffusers (Pictures 10 and 11). Ceiling-mounted vents return air to the AHUs (Picture 12), which are located in a rooftop penthouse (Picture 13). CEH staff examined a number of diffusers and returns for function. Those examined appeared to be operating accordingly, indicating that AHUs were operating at the time of assessment.

One room (i.e., room 147) lacked both mechanical and a natural supply of fresh air. A fresh air source is necessary for the dilution of indoor air pollutants. Consideration should be given to undercutting doors to this room to allow air exchange. In addition, occupants in the physical therapy room (room 159) expressed difficulties with opening doors leading to the hallway. It appears that this room has a supply source as well as a door leading to the exterior, which is described as being drafty. These two supply sources, and the lack of exhaust ventilation, may be pressurizing the classroom, resulting in difficulties in opening doors to the hallway. Consideration should be given to undercutting to reduce classroom pressurization.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced subsequent to installation to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing was unknown at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the

ventilating system is malfunctioning or the design occupancy of the room is being exceeded.

When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see [Appendix A](#).

Temperature readings ranged from 71° F to 76° F, which were within the MDPH comfort guideline. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. It is often difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (univents deactivated/obstructed, exhaust vents blocked).

The relative humidity measurements ranged from 45 to 57 percent, which were also within the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and

irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of areas throughout the school had water-stained ceiling tiles (Picture 14). Some ceiling tiles in the hallway appeared to be recently damaged and visibly wet (Picture 15). TES staff indicated leaks are primarily related to roof damage. The majority of water-damaged ceiling tiles were observed in the 1989 portion of the building, the of which is original to the building. Plans to replace the 1989 portion of the roof are on a capital projects list. The roofs for both the 1952 and 1998 wings date to 1998. Water-damaged ceiling tiles can provide a source of mold growth and should be replaced after a water leak is discovered and repaired. Appropriate measures should also be taken to minimize the aerosolization of particulates from tile removal/replacement.

Other sources for potential water damage were observed. Open seams between the sink countertop and backsplash were observed in several rooms (Picture 16). If not watertight, water can penetrate the seam, causing water damage. In addition, the interior of a cabinet beneath a sink was noted to be water damaged (Picture 17). Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell, show signs of water damage and lead to potential mold growth.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged

porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

Plants were noted in several classrooms, some on top of univents (Picture 1). Some plants were placed on carpeting (Picture 18). Plants should be properly maintained and equipped with drip pans. Plants should be located away from ventilation sources (e.g., univents) to prevent aerosolization of dirt, pollen or mold. Plants should not be placed on porous materials such as carpets, because water damage to porous materials may lead to microbial growth.

A passive crawlspace vent was observed near a univent fresh air intake (Picture 19). Plants and other materials were also located outside the building near univent fresh air intakes (Pictures 20 and 21). Odors and materials from the crawlspace, plants and materials in close proximity to univent fresh air intakes may be entrained and subsequently distributed into the classroom. Consideration should be given to directing crawlspace exhaust away from fresh air intakes. Plants and other materials should be removed and placed away from univent fresh air intakes.

Shrubbery and other plants were growing in close proximity to the foundation. The growth of roots against the exterior walls can bring moisture in contact with wall brick. Plant roots can eventually penetrate the brick, leading to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope, providing a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

A number of breaches were seen around the building exterior. Missing mortar was observed in a number of areas (Picture 3). A number of utility holes were also observed (Picture 22). Holes, breaches, and seams are points through which water can penetrate the building,

particularly under driving rain conditions. Excessive exposure of the exterior brickwork and foundation to water can result in structural damage.

Soffit vents were observed to be missing from a roof at the rear of the building (Picture 23). The missing vents create an opening that has allowed birds to enter and roost in the roof, as evidenced by nesting materials observed through the vents and birds observed flying in and out of the missing vent area. Birds can be a source of disease, and bird wastes and feathers can contain mold, which can be irritating to the respiratory system.

Exposed fiberglass insulation was also observed hanging out from the missing soffit vent. If moistened, fiberglass insulation can wick and hold moisture against the building exterior. Over time, moisture held against a building can cause damage to the exterior wall. In addition the paper backing of insulation can provide a medium for mold growth, if wetted repeatedly.

Other IAQ Evaluations

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM_{2.5}) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, CEH staff obtained measurements for carbon monoxide and PM_{2.5}.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute

health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it is present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). Carbon monoxide levels measured in the school were ND, except in room 156 where a carbon monoxide level of 1 ppm was measured (Table 1). A car observed idling outside of this classroom is likely the explanation of the recorded carbon monoxide level. TES staff expressed concerns regarding

idling of vehicles near the school. Periodically, odors from vehicle exhaust are entrained into univent systems. According to staff, these odors have a tendency to linger. Idling vehicles can result in vehicle exhaust infiltration into the building. In turn this can provide opportunities for exposure to products of combustion, including carbon monoxide. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1996).

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu\text{g}/\text{m}^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 65 $\mu\text{g}/\text{m}^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 17 $\mu\text{g}/\text{m}^3$ (Table 1). PM2.5 levels measured were between 8 to 24 $\mu\text{g}/\text{m}^3$ in the main CS building, which were below the NAAQS of 65 $\mu\text{g}/\text{m}^3$ (Table 1). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system,

cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted during the assessment. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC concentrations were also ND (Table 1).

In an effort to identify materials that can potentially increase indoor TVOC concentrations, CEH staff examined classrooms for products containing these respiratory irritants. Several classrooms contained dry erase boards and dry erase board markers, and many dry erase board trays contained dry erase particles. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Cleaning products were found on countertops and in unlocked cabinets beneath sinks in some classrooms (Picture 24). Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. In addition, plug-in air fresheners/deodorizers were in use in some classrooms (Picture 25). These products contain chemicals that can be irritating to the eyes, nose and throat of sensitive

individuals. Furthermore, air fresheners do not remove materials causing odors, but rather mask odors that may be present in the area.

An aerosol canister of pyrethrin-based insecticide was observed in one classroom (Picture 26/Table 1). Pyrethrins have been associated with cross sensitivity in individuals who have ragweed allergy (EPA, 1992). Application of this product should be in accordance with the federal and state rules and regulations that govern pesticide use, including posting and notification requirements (333 CMR 13.10). Under no circumstances should untrained personnel apply this material on school properties. This product should not be applied prior to or during school hours. Under current Massachusetts law (effective November 1, 2001), the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can introduce chemicals into the indoor environment that can be sources of eye, nose and throat irritation.

Other conditions that can affect indoor air quality were noted during the assessment. The interiors of several univents were examined. Spaces were observed around heating pipes that penetrate through the floor (Picture 27). Spaces of this nature can result in the draw of air and debris from the wall cavity or crawlspace, which can then be distributed to classrooms via the univent fan.

A number of ceiling- and wall-mounted exhaust vents were occluded with dust. If exhaust vents are not functioning, backdrafting can occur and aerosolize dust particles. As discussed, dust can be a source for eye and respiratory irritation. Once aerosolized, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently become re-aerosolized, causing further irritation.

CEH staff inspected and found univent filters in a number of areas to be coated with dirt/dust and accumulated material (Picture 28). A debris-saturated filter can obstruct airflow and may serve as a reservoir of particulates that can be re-aerosolized and distributed to occupied areas via the ventilation system.

Also of note was the amount of materials stored inside classrooms (Picture 29). In classrooms throughout the school, items were observed on windowsills, tabletops, counters, univents, bookcases and desks. The stored materials in classrooms provide surfaces for dust to accumulate. Accumulation of these items (e.g., papers, folders, boxes) makes cleaning difficult for custodial staff. Dust can be irritating to eyes, nose and respiratory tract.

Accumulated chalk dust was seen in some classrooms. Chalk dust is a fine particulate that can easily become aerosolized. Once aerosolized, chalk dust can become irritating to eyes and the respiratory system. Similarly, pencil shavings were observed to be accumulating at the base of pencil sharpeners. In one classroom, a pencil sharpener was located in front of a fan (Picture 30). When operating, the fan can serve to aerosolize and distribute these materials.

A number of classrooms contained upholstered furniture and pillows (Picture 31). Upholstered furniture is covered with fabric that encounters human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent (e.g., during spring/summer), dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended that if upholstered furniture were present in schools, it should be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICRC, 2000).

An inactive insect nest and other items were noted suspended from the ceiling system in one classroom (Picture 32). Nests can contain bacteria and may be a source of allergenic material. Nests should be placed in resealable bags to prevent aerosolization of allergenic material. In addition, items should not be suspended from ceiling tile systems. Movement of ceiling tiles may aerosolize dust above ceiling tiles. Moreover, heavy items may damage the ceiling tile frames.

A number of aquariums and terrariums were located in classrooms. Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth.

Lastly, food in open areas and the reuse of food containers were observed (Picture 33). Food is an attractant to pests and rodents. Proper food storage is an integral component in maintaining indoor air quality. Food should be properly stored and clearly labeled. Reuse of food containers is not recommended since food residue adhering to the surface may serve to attract pests.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Examine each univent for function. Operate univents while classrooms are occupied.
Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
2. Examine exhaust vents for function and make repairs as necessary.

3. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
4. Remove all obstructions from univents and exhaust vents to facilitate airflow. Close classroom doors to improve air exchange.
5. Remove debris and dust accumulated on the ventilation grilles.
6. Use openable windows in conjunction with classroom exhaust vents to facilitate air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
7. Consider adopting a balancing schedule for mechanical ventilation systems every 5 years, as recommended by ventilation industrial standards (SMACNA, 1994).
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).
9. Continue with plans to replace roof the roof of the 1989 portion of the building. Replace water-damaged ceiling tiles. These ceiling tiles can be a source of microbial growth. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial. Appropriate measures should also be taken to minimize the aerosolization of particulates from tile removal/replacement.

10. Seal breaches, seams, and spaces between sink countertop and backsplash to prevent water damage.
11. Examine sink pipes for leakage. Ensure clapboard sink cabinet is dried appropriately; make repairs/replace as necessary.
12. Examine plants in classrooms for mold growth in water catch basins. Disinfect water catch basins if necessary. Remove plants from ventilation sources and carpeted areas.
13. Remove plants growing against building and its foundation to prevent water intrusion through brickwork.
14. Clear plant growth and other materials/debris away from the proximity of univent air intakes.
15. Consider repointing building exterior. Seal breaches to the building exterior to prevent pest and water intrusion.
16. Replace missing soffit vents after cleaning interior area of any debris or bird-related materials/wastes.
17. Use appropriate precautions (e.g., wearing protective equipment) when cleaning areas above soffit vents and when removing damaged insulation.
18. Examine damaged fiberglass insulation and replace if necessary.
19. Clean chalkboards and dry erase board trays regularly to avoid the build-up of particulates.
20. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled.
21. Refrain from using strongly scented materials (e.g., air fresheners) in classrooms.

22. Remove insecticide from classroom. Application of any pesticide product should be in full compliance with the federal and state rules and regulations that govern pesticide use including posting and notification requirements (333 CMR 13.10).
23. Seal breaches around pipes in univent cabinet.
24. Consider changing univent filters on a more frequent basis to prevent reduced airflow to classrooms.
25. Clean and maintain aquariums and terrariums to prevent bacterial/microbial growth and associated odors.
26. Relocate pencil sharpeners away from fans.
27. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
28. Store nests in resealable bags, away from ventilation sources.
29. Refrain from hanging objects from ceiling tile systems.
30. Consider adopting the US EPA document, *Tools for Schools* (US EPA, 2000b), as a means to maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at <http://www.epa.gov/iaq/schools/index.html>.
31. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://mass.gov/dph/indoor_air

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Picture 1



Classroom univent in 1952 wing, note plants

Picture 2



Classroom univent in 1998 wing, note blockages

Picture 3



Univent fresh air intake

Picture 4



Items placed on and in front of univent, note clay figurines

Picture 5



Undercut closet door

Picture 6



Closet exhaust vent, notice items on shelf below vent

Picture 7



Cubby-style exhaust

Picture 8



Blockage to cubby-style exhaust

Picture 9



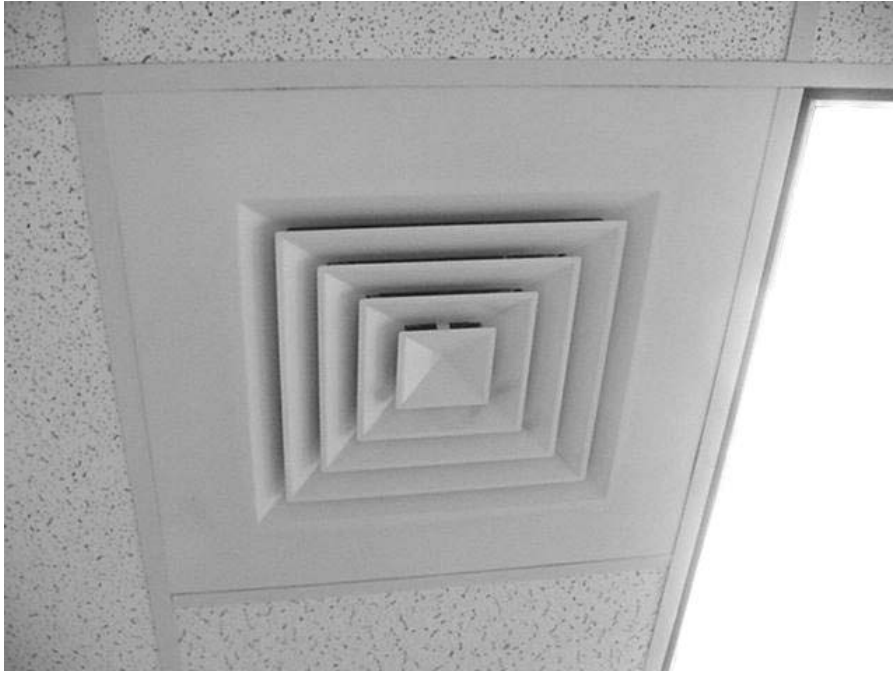
Ceiling exhaust vent near hallway door

Picture 10



Ceiling-mounted slotted air diffuser

Picture 11



Ceiling-mounted directional air diffuser

Picture 12



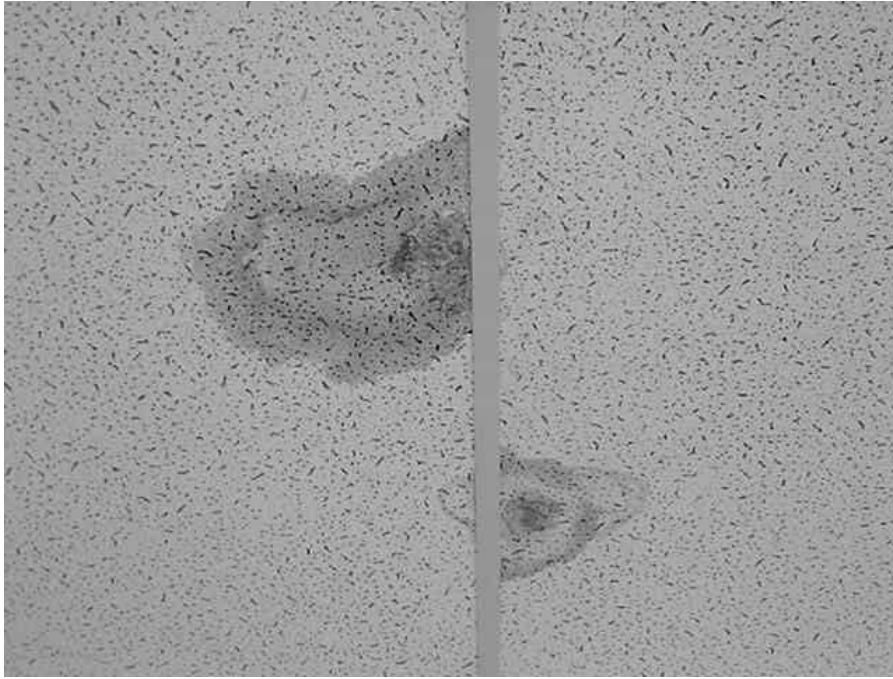
Ceiling-mounted return vent

Picture 13



Rooftop AHU penthouse

Picture 14



Water-damaged ceiling tiles

Picture 15



Moist ceiling tiles

Picture 16



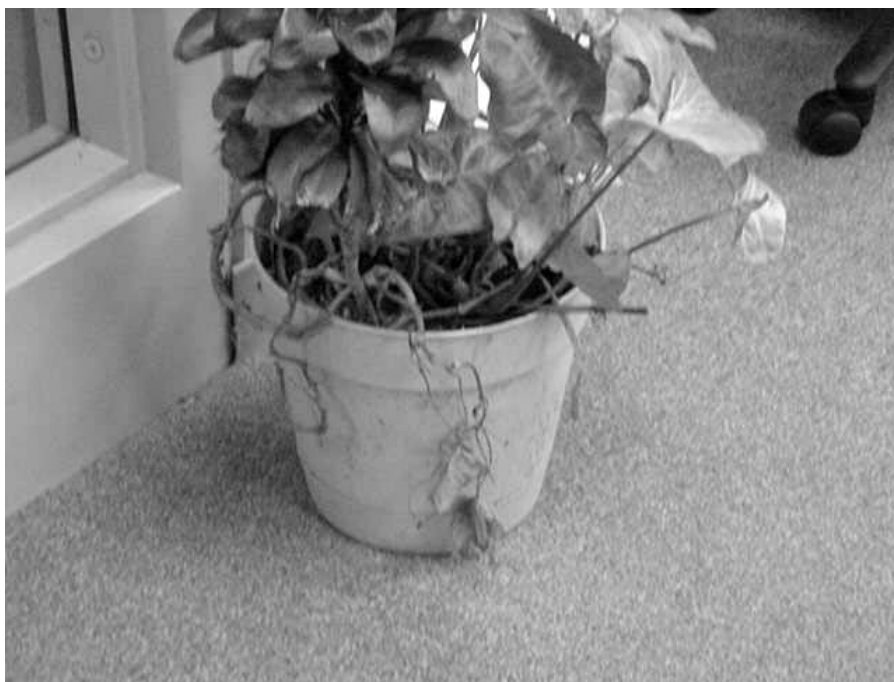
Breach between sink countertop and backsplash

Picture 17



Moistened sink cabinet

Picture 18



Plant on carpet

Picture 19



Crawlspace vent below univent fresh air intake

Picture 20



Plants near univent fresh air intake

Picture 21



Materials and garbage near univent fresh air intake

Picture 22



Open utility hole

Picture 23



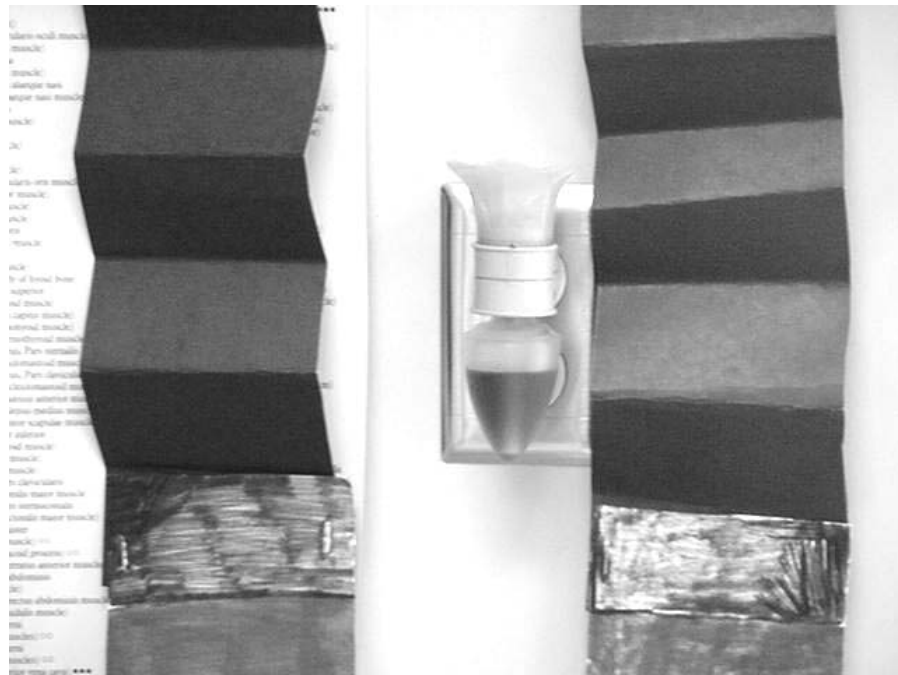
Missing soffit vent with exposed fiberglass insulation

Picture 24



Assortment of cleaners and disinfectants

Picture 25



Plug-in air deodorizer

Picture 26



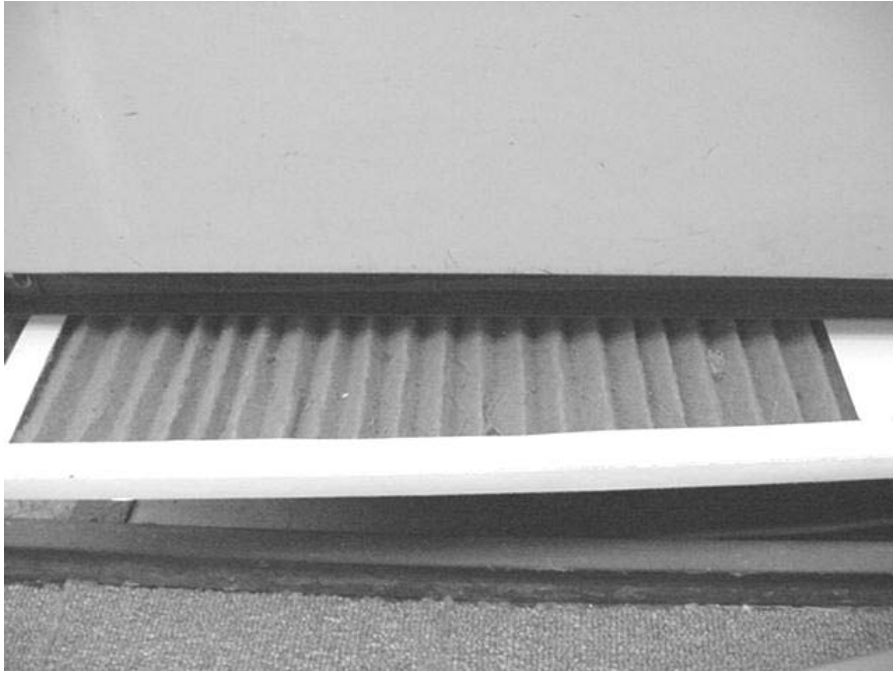
Aerosol canister of insecticide

Picture 27



Breach around pipe, univent interior

Picture 28



Occluded univent filter

Picture 29



Placement and storage of materials

Picture 30



Pencil sharpener in front of fan

Picture 31



Upholstered furniture and pillows

Picture 32



Insect nest suspended from ceiling

Picture 33



Reuse of food containers

Taft Elementary School
16 Granite St, Uxbridge, MA 01569

Indoor Air Results
Date: 06/01/2005

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		68	50	459	ND	ND	17				
Art	21	72	54	756	ND	ND	13	Y # open: 0 # total: 6	Y ceiling	Y ceiling	Hallway DO, DEM, items.
boys room	0	73	55	763	ND	ND	23	N # open: 0 # total: 0	N	Y ceiling (weak)	Hallway DO
cafeteria	150	72	54	867	ND	ND	21	Y # open: 0 # total: 0	Y ceiling	Y wall	Hallway DO,
nurse's office	1	74	48	605	ND	ND	16	N # open: 0 # total: 0	Y ceiling	Y ceiling location	Inter-room DO, plants.
guidance	1	74	48	504	ND	ND	21	N # open: 0 # total: 0	Y ceiling	Y ceiling	#WD-CT :1.

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AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

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DEM = dry erase materials

design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

M = mechanical

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ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

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sci. chem. = science chemicals

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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Table 1-1

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									Supply	Exhaust	
library	0	75	50	766	ND	ND	16	N # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 15, PF, items hanging from CT.
129	15	74	48	700	ND	ND	20	Y # open: 0 # total: 6	Y univent	Y closet (off) dust/debris	WD-CP, plant(s) on carpet, DEM, plants.
130	7	74	49	699	ND	ND	21	Y # open: 0 # total: 6	Y univent	Y closet (off)	DEM, PS, cleaners, plants.
133	0	74	48	907	ND	ND	20	Y # open: 0 # total: 6	Y univent (off)	Y closet (off)	Hallway DO, DEM, items.
138	0	73	48	625	ND	ND	19	Y # open: 0 # total: 8	Y univent		Hallway DO, PF, UF.
140	17	74	46	866	ND	ND	24	Y # open: 1 # total: 6	Y univent	Y closet (off)	Hallway DO, DEM, PF, UF, plants.

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									Supply	Exhaust	
143	5	75	45	610	ND	ND	17	Y # open: 0 # total: 6	Y univent (off)	Y closet (off)	Inter-room DO, window-mounted AC, room subdivided into four 'rooms'.
147	1	75	48	1239	ND	ND	23	N # open: 0 # total: 0	N	N	Hallway DO, items.
153	15	73	50	680	ND	ND	19	Y # open: 0 # total: 6	Y univent dust/debris	Y ceiling dust/debris	WD-CP, UF, cleaners, items, plants.
154	17	73	52	887	ND	ND	21	Y # open: 0 # total: 6	Y univent	Y floor (weak)	Hallway DO, WD-CP, PF, UF, items, plants, Comments : cubby exhaust.
155	20	74	52	1408	ND	ND	19	Y # open: 0 # total: 6	Y univent	Y floor (weak)	Hallway DO, CD, DEM, items, cubby exhaust.
156	18	74	50	944	1	ND	21	Y # open: 0 # total: 6	Y univent plant(s)	Y wall items	Hallway DO, breach sink/counter, cleaners, items, plants.

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									Supply	Exhaust	
159 (PT)	3	74	49	692	ND	ND	24	N # open: 0 # total: 0	Y wall	N	doors difficult to open.
gym 170	0	73	57	722	ND	ND	17	N # open: 0 # total: 0	Y wall	Y wall	Hallway DO,
183	0	75	48	783	ND	ND	8	N # open: 0 # total: 0	Y ceiling	Y ceiling location	Inter-room DO,
184a	20	73	51	763	ND	ND	12	Y # open: 0 # total: 4	Y ceiling	Y ceiling dust/debris	#WD-CT: 1, DEM, cleaners, items.
184b	10	75	47	778	ND	ND	9	N # open: 0 # total: 0	Y ceiling	Y ceiling	#WD-CT: 14, DEM, UF, cleaners, items hanging from CT, pets.
187 (computers)	1	76	49	688	ND	ND	19	Y # open: 1 # total: 4	Y univent	Y ceiling	Hallway DO, #WD-CT: 4, 26 computers.

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									Supply	Exhaust	
192	21	74	49	940	ND	ND	13	Y # open: 0 # total: 2	Y ceiling	Y ceiling	window-mounted AC, #WD-CT : 2, #MT/AT : 1, CD.
193	21	74	48	780	ND	ND	13	Y # open: 1 # total: 2	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 1, WD-other, CD, DEM, WD-sink cabinet.
194	15	73	48	868	ND	ND	10	Y # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway DO, CD, DEM, PF, UF, cleaners, pesticides.
195	19	74	49	1038	ND	ND	12	Y # open: 0 # total: 2	Y ceiling	Y ceiling	window-mounted AC, #WD-CT : 4, #MT/AT : 2, CD, PF, cleaners.
198	21	74	50	1054	ND	ND	12	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 7, #MT/AT: 1, CD.
199	20	73	49	908	ND	ND	10	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 2, CD, cleaners.

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									Supply	Exhaust	
201	21	74	49	985	ND	ND	10	Y # open: 0 # total: 2	Y ceiling	Y ceiling	#WD-CT: 4, #MT/AT : 1, CD, items, dust.
202	20	74	48	852	ND	ND	12	Y # open: 1 # total: 2	Y ceiling	Y ceiling	Hallway DO, window-mounted AC, #WD-CT: 2, #MT/AT: 1, CD, PF, items, plants.
204	21	74	47	825	ND	ND	12	Y # open: 1 # total: 2	Y ceiling	Y ceiling	Hallway DO, window-mounted AC, #WD-CT: 2, #MT/AT : 1, CD, DEM, cleaners.
205	19	73	53	967	ND	ND	12	Y # open: 0 # total: 2	Y ceiling	Y	CD, DEM, UF.
hallway (near rm 205)	0							N # open: 0 # total: 0			#WD-CT: 8, bowed CT, Comments: some CT visibly wet.
222	19	71	48	619	ND	ND	19	Y # open: 0 # total: 4	Y univent items furniture	Y ceiling location dust/debris	Hallway DO, breach sink/counter, bowed CT, AD, DEM, PF, cleaners, items, items hanging from CT.

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									Supply	Exhaust	
223	23	71	52	768	ND	ND	17	Y # open: 0 # total: 4	Y univent	Y ceiling	Breach sink/counter, DEM, aqua/terra, items hanging from CT, plants, dust on window.
224	23	72	52	802	ND	ND	18	Y # open: 0 # total: 4	Y univent furniture	Y ceiling	Breach sink/counter, aqua/terra, cleaners, items hanging from CT, nests.
225	21	71	51	773	ND	ND	18	Y # open: 0 # total: 4	Y univent dust/debris	Y ceiling	Breach sink/counter, DEM, aqua/terra, cleaners, nests, plants.
226	20	72	53	816	ND	ND	14	Y # open: 0 # total: 4	Y univent	Y ceiling location	breach sink/counter, DEM.
229 (music)	1	72	50	775	ND	ND	14	Y # open: 0 # total: 7	Y univent	Y ceiling	Hallway DO, #WD-CT: 2, breach sink/counter, DEM.
235	1	71	51	687	ND	ND	18	Y # open: 0 # total: 4	Y univent	Y ceiling location	Hallway DO, DEM.

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									Supply	Exhaust	
236	0	72	51	694	ND	ND	13	Y # open: 0 # total: 4	Y univent items furniture	Y ceiling location	Hallway DO, breach sink/counter, DEM, cleaners, items.
237	20	71	51	792	ND	ND	18	Y # open: 0 # total: 4	Y univent (off) items furniture	Y ceiling location	Hallway DO, #MT/AT : 1, DEM, cleaners, plants.
238	21	71	51	673	ND	ND	20	Y # open: 0 # total: 4	Y univent boxes furniture	Y ceiling	Hallway DO, breach sink/counter, #MT/AT: 2, DEM, PF, cleaners, items.
245	0	72	54	1025	ND	ND	13	N # open: 0 # total: 0	Y univent plant(s)	Y ceiling location	DEM, plants.
248	18	72	52	754	ND	ND	19	Y # open: 0 # total: 4	Y univent boxes	Y ceiling	Hallway DO, breach sink/counter.

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256	19	72	53	877	ND	ND	23	Y # open: 0 # total: 4	Y univent (off)	Y ceiling	Hallway DO, DEM, plants.
257	17	72	54	997	ND	ND	16	Y # open: 0 # total: 4	Y univent boxes items	Y ceiling	Hallway DO, DEM, items, plants.
265	2	72	51	681	ND	ND	22	Y # open: 0 # total: 4	Y univent (off)	Y ceiling	Breach sink/counter, DEM, cleaners.
271	1	71	52	452	ND	ND	20	Y # open: 0 # total: 4	Y univent items furniture	Y ceiling	Hallway DO, breach sink/counter, DEM, aqua/terra, FC re-use, food use/storage, plants, dried food (husks, gourds).
278	20	71	52	696	ND	ND	20	Y # open: 0 # total: 4	Y univent	Y ceiling	Hallway DO, DEM, UF, items hanging from CT.

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